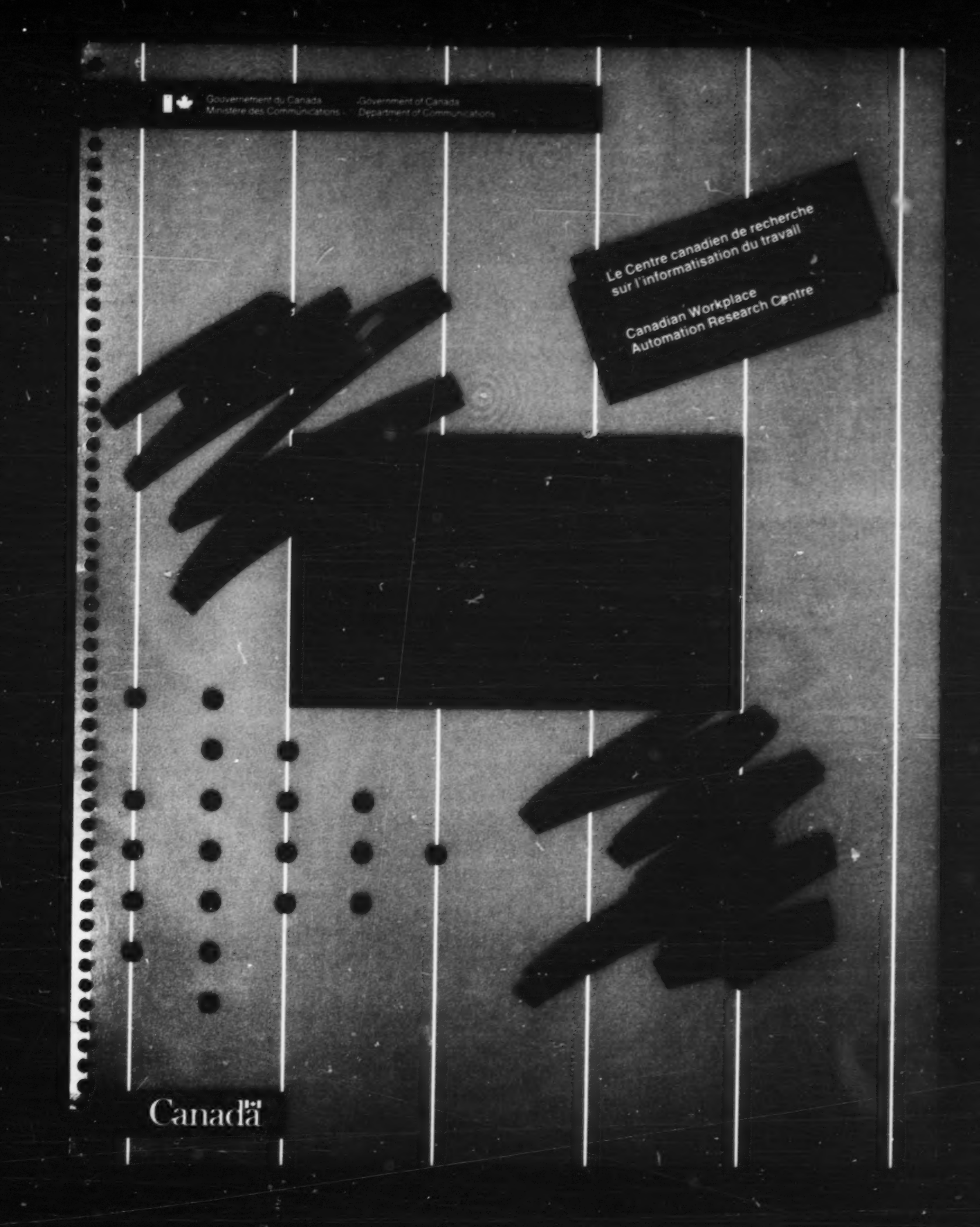
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The Impact of Technological Change on Jobs and Education

by

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Abstract

This presentation reviews and embodies the findings of recent research into the impact of new technology on jobs and education. It concludes that the job market is in flux because of the introduction and spread of new technology. Job contents are changing, jobs are tending to become more intellectually demanding; new jobs are and will be created especially in the service sector and high-tech industries; new worker profiles are called for.

This will probably lead to the introduction of key requirements in curricula: understanding systems, manipulating information using new technology, management, analysis, and decision-making.

The present educational system does not seem geared to the future needs of the job market despite the considerable efforts of various provincial departments of education to equip schools with microcomputers and systems. Programs of study that address these needs are only just being put in place.

The technological conversion poses a three-fold challenge to the educational system: to train staff that can work with the new technologies, to retrain workers affected by change and to redefine the content of school programs.

New relationships to knowledge and work are being established. This presentation suggests a variety of solutions to the various levels of government, the private sector and the public at large to deal with the impact of technology on the workplace and education.

Introduction

In the fifth millenium, the appearance of writing, with the first hieroglyphs inscribed by the Sumerians on wax tablets, marked a decisive watershed in human history.

Today, informatics seems to be plunging us into an analogous phenomenon: the extension of memory, the proliferation and transformation of information systems, the modification of some models of authority, and the creation of new processes and new concepts.[1] The pace of development is rapid.

The past few years have seen the introduction of new technologies and a ceaseless process of modernization in industry. Every day new products invade the worlds of business and research as well as the consumer's daily life: "home furnishings" now include telephones with storage memory; microwave ovens; digital sound systems; micro-computers; almost entirely programmable cars; and remote-control televisions, lighting and heating systems.

In the workplace, the majority of companies have bowed to the imperatives of higher productivity with photocopiers, word processing and sophisticated machinery. The consumer also has access to the most modern services: automated bank tellers, electronic machinery at the garage, electronic bar code readers at the supermarket checkout; in medicine, the laser and the CAT-scan are no longer mysterious. Wherever you are, the new era has arrived.

What do we expect from the technology of the future? Superconductors will soon be an everyday item! Their power, when applied in informatics, medicine, transportation and energy innovations, will revolutionize our concepts of performance and efficiency.

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1 Nora, S. and Alain Minc, L'informatisation de la société (The computerization of society), Paris, La Documentation française, 1978, p. 116.

The domination of the "stuff" of high technology in now an established fact. An overview of the new computerized age brings forth promises of productivity, the evolution of thought, the birth of a new world, awesome in its technological challenges and social changes.

But what will be the impact of these technological revolutions on our jobs in our everyday lives in the workplace?

This paper makes no claim to being an exhaustive analysis of the impact of the new technology on jobs. Its aim is rather to make educators aware of changes which are happening now in business, of the impact of technological innovation on jobs and employment, and thereby of the new demands being made on today's educational system, demands which raise a question mark over our young people's future.

Chapter 1: Technological change in the workplace as we perceive it

In every age, society has perceived technological innovation as threatening its survival. Inventions, whether they were the weaving loom, the railway or the automobile, aroused a great deal of apprehension before they were first tolerated and then incorporated into daily life.

The same is true of the advent of the computer. As a society, we are still at the stage of "taming" the environments created by the computer. Since the early 1970s, we have witnessed the appearance of a flood of new technologies in electronics, informatics and telecommunications.

Several of these technological changes have crept into our daily lives without our being aware of them: our hydro bills, plane reservations and the tabulation of election results have all been computerized for years!

Technological change is increasingly affecting our home lives through labor-saving appliances that leave more time for recreation and culture by making maintenance easier. Their impact is greater in the workplace, however, for they offer business the chance of substantial savings: not only do they consume minimal amounts of raw materials and energy, they also in many cases save money ... and labor.[2]

The effects produced by the introduction of these new technologies are numerous, but they are not the ones we would have expected in the early 1980s. The pessimists and optimists were divided, as they marshalled studies in support of their own viewpoints, while still other theses tended to adopt a neutral, fatalist or cyclical vision of the world of tomorrow.

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2 Brainard, R. and Kym Fullgrabe, "Technologie et emploi" (technology and employment), Science Technologie Industrie, Paris, OECD, 1986, p. 11.

An OECD study by Brainard and Fullgrabe (1986) attempts to place in a more scientific context and to analyze objectively all the various theses which are based on hypotheses specific to certain sectors or industries and from which it is difficult to generalize. They arrive at the following conclusion: "Technological change has had little noticeable effect on national levels of unemployment (in the OECD countries) or rates of economic growth, while shifts in the type of demand and international competition have played a much more decisive role."[3]

In fact, the main effects were reflected in a new distribution of the work force between industries and services and amongst occupations.[4]

The new technology thus affects primarily the worker and the job; hence tomorrow's workplace will depend on the introduction of these technologies.

The new technologies

The foundation of these economic and social changes is thus the constantly evolving machines, equipment, software and applications of informatics. The terms productics (production automation), bureautics (office automation), robotics, telematics, informatics and novotics (the discipline combining informatics, bureautics, robotics and telematics) conceal a multitude of machines and systems which are taking their place in increasing numbers alongside human workers.

Many of us are aware that office automation is now an integral part of the workplace, whether in the schools, the universities, small business or

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3 Brainard, R. and Kym Fullgrabe, "Technologie et emploi" (technology and employment), Science Technologie Industrie, Paris, OECD, 1986, p. 10.

4 Brainard, R. and Kym Fullgrabe, "Technologie et emploi" (technology and employment), Science Technologie Industrie, Paris, OECD, 1986, p. 11.

multinationals, the word processor and the micro-computer have become virtually indispensable to the flow of information.

Some companies have pushed their modernization programs one stage farther installing management computers, electronic records systems reprography and photocomposition. They use software in the decision-making process and even receive their messages by electronic mail.

Increasingly, organizations such as CWARC (Canadian Workplace Automation Research Centre) provide integrated automated workstations for their employees and advanced equipment such as teleconference rooms, which make it possible to hold a meeting, on the screen, with participants located at the four corners of the earth.

In medicine, many hospitals in Canada have a CAT-scan (computer-aided tomography), or even more sophisticated computerized diagnostic equipment such as SCAN RMN, isotopic ventriculography and computer-aided echography.

Companies in a variety of fields (such as aeronautics, automobiles, television, civil engineering, architecture and so on) and even some academic institutions use CAD (computer-aided design) systems, which automatically perform all the calculations needed for the design of a product simply by drawing on a specially equipped computer terminal.

In the manufacturing field (CAM), there are numerically controlled (NC) machine tools, which are used in small production runs (and are highly prized in small businesses); robots, manipulators, "flexible shops" (integrated robot systems), automatons which can be programmed for long production runs for use in industries such as automative or electronics, or industrial computers which automatically regulate continuous production, as in water works or refineries.[5] Plants with this type of equipment are to be found in

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5 Pastré, Olivier, L'Informatisation et l'emploi, (computerization and employment), Paris, Editions La Découverte, 1983, p. 15.

the chemical, electricity, cement, aluminum manufacturing, steelmaking, textiles, paper and agri-food industries.

As a consequence of the central importance of information within the service industries, this sector is increasingly well equipped in the area of new technologies. In addition to the very latest in automated office equipment, the finance industry has introduced automated bank tellers, optical readers for cheques and so on. Postal services and supermarkets use the same equipment for mail and universal bar codes.

In engineering, accounting and research, a number of companies have impressive data banks and decision-support systems with increasingly sophisticated software and increasingly intelligent computers, which they use in their operations and to manage their organizations.

Extensive research is underway into fibre optics, lasers, superconductors and artificial intelligence and a variety of applications have already begun to appear: fibre optics are being used in telecommunications and in medicine; and lasers are being used in medicine, in digital equipment (such as sound systems), in lighting, in the arts and so on.

The determinants of technological innovation

We are well aware of some of the technological changes going on around us, but do we know the reasons why they are being introduced? Before we examine the effects of new technologies on jobs, it might be interesting to take note of what motivates business to modernize.

According to a survey by Guylaine Vallée (1986) of companies in the primary and secondary sectors, certain factors have characteristics which are specific to the company (size, field of activity, foreign control, technological experience) and others which are a function of the economic and technological environment.

The presence of problems or pressures in the company's socio-economic environment is one of the most important factors in motivating a strategy for change. Competition is the spur! Another key factor, anticipated trends in demand for a product, also stimulates businesses to act. A reduction in the cost of labor, a decline in the rejection rate, better use of raw materials, energy conservation, reduction in manufacturing time, flexibility and quality in production - these are all factors which encourage change.[6]

Taken together, economic considerations and considerations stemming from a changing value system motivate a company to install new equipment. In 1966, in a report on workers' adaption to change, the OECD stressed "the need to be fully aware of workers' attitudes towards technological progress" in order to avoid socially and economically negative consequences, "since now more than ever before, workers can, by their behavior and their actions, influence the pace of change and the extent to which its promise is fulfilled."[7]

Every country, including Canada, can establish an acceptable level of employment for its citizens depending on the capacity of its work force to adapt to technological change and whether or not it gains a lead on its competitors in the introduction of advanced technology.

The political and economic aspects of this statement go beyond the scope of this paper. On the other hand, the adaptability of the work force is one of the considerations discussed in the following chapter, since the impact of technological change on jobs is one of the determinants of the future employment situation in Canada.

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6 Vallée, Guylaine, Les changements technologiques et le travail au Québec (technological change and employment in Quebec), Quebec City, Government of Quebec, 1986, p. 31-32.

7 Guimond, S. and Guy Bégin, Le choc de l'informatique (the informatics shock), Quebec City, Presses de l'Université du Québec, 1987, p. 40.

Chapter 2: The impact of technological change on jobs

In order to illustrate the impact of technological change on jobs, let us look at the example of the manufacturing sector, which was the first to be affected by robotization.

According to R. Ayres and S. Miller, robotics would appear to be the factor with the most detrimental impact on manufacturing jobs. Although the purpose of many robots is to increase productivity, the quality of production and, hence, profitability, are becoming increasingly versatile and in a few years will be able to replace more workers, especially relatively unskilled ones.

In contrast, the Bureau of Labor Statistics estimates that U.S. high-technology companies will create between 730,000 and one million jobs by 1993. A large majority of these jobs will be unskilled, even though the highest growth will come from skilled jobs. For example, the number of operators will increase by 42 percent (to 377,000) while the number of engineers and technicians will increase by 60 percent (to 56,000) within a decade. It is nevertheless true that in the short term these industries in the secondary sector primarily destroy jobs rather than create them, since some of their products will have a potentially significant impact on the volume of the work force in other industries. Thus, while industrial robots may create between 3,000 and 5,000 jobs, they will on the other hand cause up to 50,000 to disappear in the automobile industry.

In this context, General Motors estimates that one robot replaces on average 1.7 workers on the assembly line and 2.7 in manufacturing.

The loss of jobs in industry as a result of the introduction of robots on a massive scale does not seem so important, however, since "increasing numbers

of skilled workers" (specialists in microeletronics, executives, salespeople) will be required, thus compensating for the redundancies amongst unskilled workers. The unskilled can in any event be retrained, since two-thirds of them are convered by seniority clauses or clauses relating to technological change. There is also the effect of transfering from one sector to another: in other words, from the industrial (secondary) sector to the "soft services and trade" (tertiary) sector. The problem lies in the absorptive capability at the time of the substitution.

As you can see, the consequences of this type of modernization for companies' logistical support are many: the increase in productivity sustained by new technologies promises an improvement in the general standard of living, a less inflationary economy and an industry that is more competitive in international markets.[8]

On the other hand, on a more personal level, job quality and the distribution of the number of jobs available will be greatly affected.

A reduction in the work force in the primary and secondary sectors is already apparent; by contrast, there is a significant observable increase in services and an upsurge of activities in which information is the raw material.[9]

The process of job change is already underway: more and more is heard about the displacement of workers, retraining, worker replacement, the demand for skilled manpower, and the content of altered jobs. What will the new job content be prompted by the new technology?

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8 O'Toole, J., "Getting ready for the next industrial revolution," The world of Work, Bethesda, World Future Society, 1983, p. 233.

9 Nora, S., and Alain Minc, op. cit., p. 113.

New job content

Many people are aware that jobs are changing and acquiring new content. We have only to glance through the "Careers" section of the classified advertisements in any newspaper to realize that the skills sought are not the ability to handle a saw or a hammer but to work with data, theories and knowledge.[10]

Because of learning time and cultural resistance, we must realize that change always takes longer than expected for a critical mass to adapt to these technologies. The technology is there, but it can be brought on stream only at the pace of human learners. Several innovations are nevertheless already in operation in various sectors of the workplace.

A number of jobs require an understanding of more complex new technologies:

1. In the office, familiarity with a computer and use of all the machine's capabilities will become necessary. Secretaries are seeing their typewriters, files and even the postal systems gradually replaced by word processing, a computerized records management system and soon a video transmission communications system.

2. In the factory, human employees will install, program or repair the robots who will perform the more basic tasks.

3. In the banks, tellers no longer have more than a handful of operations to perform following the introduction of quick deposit boxes, automated tellers and bankbook updating by printout. Their work is thus punctuated by a great deal of down

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10 Coates, J.F., "The changing Nature of Work," The World of Work, Bethesda, World Future Society, 1983, p. 25.

time and there can be little doubt that the job content will be expanded.

4. In wholesale and retail businesses, computerized access to information has made possible an increase in the speed with which business operates by automating inventory control and distribution systems, by establishing direct contact between the customer and the warehouse, and the introduction of universal bar codes and so on.

   Delivery persons, bookkeepers and stock record keepers, buyers and shippers, sales staff and management have all seen their job content expand and change.

5. In the hospital and health services sector, microelectronics first appeared in inventory control and information retrieval (patient files, equipment and drug inventories, billing, payroll and so on). The next step will be computerized diagnosis, although to a certain extent it already exists (basic tests, etc.); technology has also made inroads in such ancilliary services as laundry and kitchens. As far as the professionals are concerned, microelectronics has created new paramedical professions. It has also spurred the creation of interdisciplinary teams.

6. In the insurance industry, the first wave of computerization was directed towards providing improved customer service through electronic data processing between head office and branches, the transfer of certain tasks such as sales and billing to computers, word processing and electronic funds transfers.

   The second wave will have as its aim the integration of the various systems, while enabling computers to play a role in the

decision-making process through the abundance of accurate data they make available.

Computerization will therefore lead to an expansion of this industry with a concomitant increase in jobs: one can already see insurance agents calling on their customers, computer in hand. Services will be tailor-made, the results instantaneous on sales ...!

7. In transportation, whether in public transportation by surface, air or rail, the introduction of on-board microelectronics will increase efficiency in terms of speed, size, maintenance and energy consumption. Computerization will also occur in some air traffic control, switching and signalling systems as well as in marketing. It goes without saying that there will be an inevitable rise in the number of workers associated with computers.[11]

New jobs

All these changes have forced employers to review their requirements with regard to job distribution. This does not mean less work (although research findings are divided on this point[12]), but rather different work. By the turn of the century, 86 percent of the work force will be employed in the service sector, compared to 68 percent in 1980.[13] People will no longer work in the automobile, steel, textile, rubber or railway industries: they

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11 According to a bibliographic directory of the Institut National de Productivité (INP) in Montreal entitled Changements technologiques (technological change).

12 Nora, S., and Alain Minc, op. cit., p. 15.

13 Cetron, Marvin J., "Jobs with a Future," The World of Work, Bethesda World Future Society, 1983, p. 187.

will have to develop new skills to meet the demands of new markets based on high technology.

The high-technology sectors consist of industries with a high R&D content: manufacturing industries whose products are based on R&D and new technology; industries involved in computers, communications, including equipment, instruments and electronic components, and aerospace. High-tech industries also include a wide variety of companies dealing with energy innovations, lasers, biotechnology, robotics, chemicals, new medical products and leisure products for the consumer market.[14] [15]

These new businesses have transformed the job market and created a demand for specific types of jobs to the detriment of some other sectors, such as agriculture, manufacturing and unskilled labor in general.

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14 The California Commission on Industrial Innovation, "Preparing California's Work Force for the Jobs of the Future," The World of Work, Bethesda, World Future Society, 1983, p. 273.

15 Brainard, R. And Kym Fullgrabe, op. cit., p. 27.

TABLE 1

The Shifting Job Market

Some jobs that will be disappearing by 1990

Occupation	% Decline in Employment
Linotype operator	-40.0
Elevator operator	30.0
Shoemaking machine operators	19.2
Farm laborers	19.0
Railroad car repairers	17.9
Farm managers	17.1
Graduate assistants	16.7
Housekeepers, private household	14.9
Childcare workers, private household	14.8
Maids and servants, private household	14.7
Farm supervisors	14.3
Farm owners and tenants	13.7
Timber cutting and logging workers	13.6
Secondary school teachers	13.1

Source: Cetron, Marvin J., Jobs with a Future, 1984.

TABLE 2

Attractive Jobs for the Year 2000

	New Jobs Created by the Year 2000
TELEMARKETING OPERATORS	8,000,000
CAD/CAM WORKERS (COMPUTER-AIDED DESIGN AND MANUFACTURING)	1,200,000
SOFTWARE DESIGNERS	1,000,800
GERIATRIC ATTENDANTS	600,000
HOUSE RENOVATORS	490,000
ENERGY CONSERVATION TECHNICIANS	400,000
PARAMEDICAL TECHNICIANS	375,000
GERONTOLOGICAL ATTENDANTS	300,000
TOXIC WASTE TECHNICIANS	300,000
ENERGY STORAGE TECHNICIANS	160,000
TECHNICAL ATTENDANTS FOR THE HANDICAPPED	120,000
RADIO THERAPY TECHNICIANS	100,000
PULMONARY THERAPISTS	100,000
BIOMEDICAL ELECTRONICS TECHNICIANS	100,000
NUCLEAR MEDICINE TECHNICIANS	75,000
INDUSTRIAL HEALTH AND SAFETY TECHNICIANS	70,000
BIONIC IMPLANTATION TECHNICIANS	65,000
RADIOLOGICAL TECHNICIANS	60,000

Source: Dr. Marvin Cetron and C. Helms, Forecasting International and Occupational Forescasting (Table slightly amended).

New profiles

All these careers and others, some related, some quite different, will provide a wide variety of jobs with highly diversified responsibilities. They will demand from workers a great ability to adapt to a variety of workplaces, jobs, new concepts and products, new management styles and to a highly modern business infrastructure quite different from the one we know. Workers will therefore have to become very versatile, capable of meeting the new demands born of new discoveries.

Alvin Toffler in his book The Third Wave describes the emergence of a new type of job: offices in the home, made possible by the advent of portable computers and modems. It will thus become easier to organize working time and workers will be able to structure their work day as their own needs require: exchanges with colleagues, teamwork, individual work, etc.

Versatile; adaptable; analytical; capable of solving problems; interested in and capable of keeping up with the latest advances, or at least interested in continuing education; self-reliant; capable of making decisions or working as part of a team: these are the pre-requisites for the worker of the coming decades.

After having studied these pre-requisites for employment, one question looms large: does our present educational system meet the demands of the 1990s (the development needs of the new technologies)?

Chapter 3: How well does our present educational system meet our future needs?

Do you realize, those of you who are educators, psychologists, economists and researchers, that the students who will be the high-school graduating class of the year 2000 will be starting elementary school in less than two years?

Are the schools that will guide these students, and which in principle will educate Canadians in the twenty-first century, ready to train and educate these young people to live in a world where technology will coexist with a certain quality of life?

As you have deduced, the impact on jobs will also be felt on the education of the future. What, more specifically, are these future needs in education?

New academic requirements

There will be great demand for engineers, analysts, technicians and scientist in a wide variety of high-tech fields. The job profiles will obviously require that workers be literate and numerate, but from the standpoint of acquiring the skills needed to operate highly sophisticated equipment.

Workers will also need to be able to express themselves well, to listen, measure, observe, analyze and solve problems. They will need a solid grounding in "formal logic" and "informational logistics." They will have to learn since they will need to retrain or take courses continually to keep up with technological developments or to get ahead.

While most of the new jobs will require a community college or university education as a starting point, it is clear that a degree of familiarity with sophisticated equipment will be necessary, as will the ability to take continuing education courses to refresh their knowledge.

Scenario: Future needs in education

A number of Canadian, American and French experts have attempted to forecast what the school of tomorrow will be like. Current trends in the job market and the needs of business and the population are establishing precise and relevant demands which the present educational system meets only partially.

The following scenario is merely one of several. It is not possible to give a precise time frame for it, since it is only a forecast. It nevertheless outlines certain requirements of the world of work of which educators and governments ought to be aware.

According to Marvin Cetron,[16] the 1990s will see a general reduction in the work week to 32 hours and then to 20 hours. Many people will use their new-found leisure time to prepare themselves or study for a new job. The school week will thus be much longer than it is today, with schools remaining open 24 hours a day to provide computer laboratories, job simulation laboratories and recreational facilities to the community, business and young students.

After the school day is over for the young students or for a mixed clientele of young people and workers, schools will become training and retraining centres for working people from 4:00 p.m. to midnight.

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16 Cetron, Marvin, Schools of the Future, New York, McGraw-Hill Book Company, 1985, p. 14.

Classrooms will be equipped with electronic learning equipment. Some students will be able to accelerate their studies in order to join the job market earlier, or study during the summer to enhance their stock of knowledge, using telecommunications facilities to take courses in other schools, cities or countries.

Some students will be able to study at home using on-line microcomputers. With personalized course programs and electronic learning equipment, students will finally have the benefit of individualized teaching, as a result of the flexibility of teachers, school resources and new educational approaches.

Schools and business will work as a team, exchanging services, teachers and specialized workers. This will make it possible to establish cooperative work-study programs at the high school level to give students a better feel for the work place and to better meet their aspirations.

The situation of the educational system

All this is of course only a look into the future. But is it really so unrealistic if we compare this scenario with today's is reality in education and trends in the job market?

The working week for the average person today is 40 hours. What little free time people have is spent with their families or relaxing and not studying and retraining; according to a recent Gallup poll, Quebecers were least well informed about the race for technological leadership.[17]

The school day for young people is six hours. Between 4:00 p.m. and midnight, schools provide some recreational services for the community, such as some sports facilites and equipment, but what electronic equipment exists is locked up.

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17 Gallup poll, La Presse, June 15, 1987, p. A 2.

There are few items of electronic learning equipment, such as micro-computers in the classrooms. According to Fred Crouse of the Nova Scotia Department of Education, the situation in his province is as follows: at the elementary level, one computer for every 100 students (100:1), with a slightly better ratio of 25:1 at the secondary level. The ratio is 36:1 in Manitoba and 176:1 in Newfoundland.[18]

The inflexibility of the school system (periods of between 45 and 60 minutes, a limited choice of options, etc.) and traditional learning methods do not allow students to accelerate their progress to reach the job market ahead of time. Telecommunications and on-line micro-computers are the privilege of a minority.

The most privileged students have a micro-computer at home, and some educational software exists. The educational system, however, still has not discovered how to adapt these tools to teaching, and competence in computerized teaching still seems insufficient to achieve a balance between computer-aided teaching and current methods.

Finally, there is very little collaboration between schools and business. Large corporations provide their employees with their own training courses. A few specialists are lent to universities as guest professors or guest researchers and there are a few cooperative programs between universities and industry, such as the cooperative programs in engineering, accounting and the humanities offered by the universities of Sherbrooke and Ottawa.

The efforts being made by the provinces

The presence of educational institutions in the community and in business is thus not very visible and has been quickly overtaken by the extraordinary tidal wave of technology unleashed by the advent of the micro-computer.

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18 Government of Alberta, Computers in Elementary Education, February 1987, p. 4.

In Quebec, an educational policy has been devised to allow school boards to buy micro-computers, train teachers and free up teachers in order to create educational software. The government's intention is laudable, but money is so scarce that the critical mass has not been attained. At present, micro-computers are applied and used in class due to the voluntary involvement of individual teachers, even though a basic high-school course in programming has been introduced with the title of "Introduction to computer science."

In Ontario, classrooms generally have computers, but there is still no sign of a statement of provincial policy. The Ministry of Education does not at present have statistics on the number of minutes a student spends on a computer per day or per week.

In Nova Scotia, an action plan will be announced in September 1987 regarding the introduction of computer science in elementary and high schools. At the elementary level, funds will be provided to encourage teachers to use computers in class for writing, illustrations and simulations. At the high-school level, programs have been devised to use word processing, data bases complied in cooperation with the municipalities, museums and so on. Computers will also be used in mathematics, science and for problem solving.

Alberta has invested time and money in setting up programs at both the elementary and secondary levels and equipment has been distributed on the basis of which a ratio of 20 students to a computer has been achieved.

At the university level, the courses offered endeavor to meet the needs of the market: everywhere in Canada there are courses in informatics and the engineering of new technologies. However, specialities involving robotics, cognitive science (knowledge engineering) or the information industry are either rare or the result of combining random courses in informatics, engineering and communications.

Most important, however, is the fact that the current division into the world of education and the world of adult training and retraining complicates an overview of the whole.

The future and electronic learning

Although the universities are attempting to keep up with or even get ahead of technology, the question might well be asked what will happen to the future university students of the year 2000.

These students will be starting elementary school in two years' time. Pre-school age children are already surrounded at home by electronic equipment and sometimes even micro-computers. An exploring child is no longer limited to the objects in his own environment: he can manipulate symbolic objects on a screen using a program such as "Logo". In Piaget's theory of child development, this learning process theoretically develops at a much later stage.

Is it possible that a child who has access to a world of electronic learning will undergo a different development process from a child whose world is one of print information? Mary Alice White, a psychologist at New York's Electronic Learning Laboratory,[19] theorizes that the sequence by which a child acquires knowledge may already be changing.

It must be pointed out, however, that this is purely hypothetical and that it is a widespread fallacy to overestimate the power of technological change over mankind. The modes and pace of human learning evolve only very slowly.

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19 White, M.A., "Toward a Psychology of Electronic Learning," The Future of Electronic Learning, Hillsdale, Lawrence Erlbaum Associates Inc., 1983, p. 55.

This reservation notwithstanding, let us look at the following table showing the characteristics of various familiar types of learning as a function of the learner and the content of the learning.

TABLE 3

Characteristics of Electronic Learning vs. Print Learning

Characteristic	Receptive Electronic Learning (TV, cable)	Interactive Electronic Learning (computer, interactive, cable video-disc, etc.	Print Learning
A. LEARNER			
1. Accessibility to learner	immediate	if type commands, some reading required	must learn to read
2. Level of learner attention	high	high	variable
3. Level of learner motivation	high	high	variable
4. Level of learner control	none	high	pace and sequence under user control, not text
5. Degree of mental activity required by learner	?	ask more questions	variable
6. Memory processing by learner	?	?	conflicting theories
7. Level of interaction involved	none	high	none or low
8. Degree of peer involvement	low or none	peer teaching?	low
B. CONTENT			
1. Level of entertainment	high	high	variable
2. Level of print usage	low	variable	high
3. Level of image usage	high	high	low
4. Level of sound usage	high	variable	none
5. Technical features of the medium	complex	complex	simple
6. Level of game format usage	variable	high	high

There would to be a shift in the acceptance of technology as a learning medium in relation to the traditional medium.

What is meant, however, by electronic learning? Mary Alice White proposes a definition of this new world. It is a process of learning assisted by such electronic equipment as televisions, computers, micro-computers, video-discs, electronic games, cable television, videotext, teletext and so on.[20]

Children who grow up surrounded by this electronic learning equipment are no longer part of an elite. To show that this autonomy in manipulating information is neither recent nor limited to the micro-computer, we should look at children's learning in relation to television. Children find in television an important source of information which they can retrieve themselves, since they are capable from a very early age of pressing the button and voluntarily obtaining the information expected.

It is therefore easy to feresee young people's enthusiasm for electronics-aided learning. Some studies have already been done in the United States on the attitudes of young students in computer classes. Among other things, the students ask more questions because they are more interested,[21] interact more with each other and their exchanges have to do with the learning in progress or with cooperative efforts.[22]

Even if the results of these studies must be relativized, what we are experiencing is a questioning of learning approaches. Electronic learning should fascinate us as adults and educators, since it is a type of learning

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20 Ibid., p. 51.

21 Ibid., p. 58.

22 Ibid., p. 59.

which motivates children, holds their attention, which they enjoy and which could become a means of improving child development and education.

What does school hold in store to attract and nourish their intellectual curiosity? The specific attribute of humans is their ability to react by adapting to their environment, to change. We can therefore assume that the children of tomorrow will develop ways of reacting by adapting to a new set of circumstances, to the increased presence of technology.

The challenge facing the school system is perhaps to facilitate the achievement of a balance between technology and quality of life, between traditional knowledge and learning that should be conserved and even reasserted and new knowledge that should be incorporated.

For example, the entire tradition of humanism, of reflection on the individual and society, a body of useful knowledge and learning concerning individuals, groups and their social, economic and cultural manifestations needs to be balanced against the growing role of disciplines related to the natural sciences, such as mathematics, physics, informatics and so on.

Chapter 4: What strategy of social change should our educational system adopt to meet the challenges of the job market of the 1990s?

> "Today's real failure with the young is not our inability to provide them with jobs, for the evolution of the socio-economy makes this inevitable. Our true catastrophe is that we have not educated people to grasp opportunites outside the conventional job market or to make choices among the wide range of options available within the communications era."[23]

The role of education

You have observed that our present educational systems are flagging, that a mood of disillusionment is projecting a picture--true or false--of a "decline" in the quality of teaching, of a degree of apprehension surrounding our children's future.

The Summerhill school was characteristic of the 1960s and 1970s, but today's slogans run counter to its innovative proposals. We are faced with the swing of the pendulum: the talk is of "standards of success for all," "mastery of content," "the quest for order" and "teaching values and models of behaviour."[24]

What does tomorrow hold in store? However important mathematics and science may be, it is not enough for the skills and knowledge acquired to be

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23 Theobald, Robert, "Toward full unemployment," The World of Work, Bethesda, World Future Society, 1983, p. 56.

24 Bertrand, Yves, Vers l'école de l'an 2000 (towards the school of the year 2000), Quebec City, Department of education, 1986, p. 67.

productive and satisfactory. People must learn to make decisions, to solve problems, to develop their creativity, their critical faculties, their judgment, but above all we must allow them to develop themselves in a new context.

There are many ways to achieve this and the possibilities abound. Will the efforts be consistent and the will to act shared by all? Where should we start? Educational philosophies are divided in reaching a vast audience. Each one is every bit as interesting as the next, but that does not mean they are all equally applicable and pertinent. Their achievement in the context of technological development perhaps no longer responds to needs which have themselves changed.

New educational projects reflect the desire for change in a society confronting the demands of tomorrow. In a document entitled Vers l'école de l'an 2000 (towards the school of the year 2000), Yves Bertrand traces three possible scenarios for the school of the future: the electronic media school, the school of excellence and the school of new values.

The provincial governments not only have a surfeit of choice, but they will have to formulate rapidly concrete and effective policies and strategies for closing the widening gap with onrushing technology.

Problems in education

Resistance manifests itself in numerous ways. The problems, however, have little to do with technology itself, but rather with the allocation of resources:

1. Do the schools and school boards receive enough money to buy and maintain electronic learning equipment?

2. Are funds available to train competent educators?

3. Are funds made available to workers so that they can receive continuing training and not merely one or two days of workshops a year?

Another series of problems concerns software:

1. Good educational software is scarce!

2. Among existing software, there is a pressing need in terms for standardization of content and performance.

3. An enormous job is being undertaken on a volunteer basis by teachers who are writing their own software. This involves a duplication of effort which could be avoided if there were a better communications network between the schools and the teachers.

In education, as in business, investment in "human resources" is still inadequate: in other words, the training of teachers and the tools used for the purpose are often regarded as an expense rather than as an investment in society.

The other problems related to the organization of the school system as such are:

1. Fixed terms.

2. Set class period of 45 or 60 minutes.

3. Premises are not available.

4. Schools close at a set time.

5. The roles of teachers and students.

The school's responsibilities

Schools must face up to these problems. A number of policies have already been implemented with regard to what Marvin Cetron[25] calls the schools' future responsibilities:

1. Preparing students to enter a highly volatile job market; if as a nation we wish to remain competitive in international markets, our work force must receive training on a regular basis in order to keep abreast of new technologies.

2. Preparing students to adapt to meet the future demands of high technology. In light of the estimate that workers will change jobs every 5-10 years, schools must be ready to accommodate young and old students, to train the older ones or retrain them depending on business requirements.

3. Obtaining funds to provide themselves with equipment, premises and teachers to run these job training programs.

   Opening at times convenient to working people. This implies a restructuring of the "school day" and the premises themselves.

4. Establishing links with companies to exchange services, train programs, equipment, staff and money and to keep abreast of the latest technological development so as to give students the finest education possible.

5. Paying increasing attention to "reading, writing, mathematics and the ability to communicate," for young people will have

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25 Cetron, Marvin, op. cit., p. 2-3.

to retrain themselves or take training courses on a regular and frequent basis.

6. That new technological equipment be placed in the schoools and access to it in the home be encouraged. Micro-computers, video-discs and other new electronic learning equipment will change the attractiveness as well as the pace of classroom instruction; students will also have the option of working at home. With proper planning, education aided by technology will enable teachers to teach only what they do best, supplemented by a machine that does the same thing.

7. Perhaps when the role of these changes and teachers becomes greater, their work will receive greater recognition. They will then be more motivated, the school will gain in both attractiveness and expertise and education will once again become the locomotive of our society!

The roles of government and private enterprise

While the impact of technology on jobs is inevitable, its impact on the type and number of jobs in our economy is less so. Everything depends on the people controlling the technology.[26]

Everybody in Canada with any power has an obligation to act quickly to establish a Canadian presence in the development, research and marketing of advanced technology.[27] In order to do this, however, various sectors must undertake concerted action.

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26 Levin, H.M., and Russell W. Rumberger, "The Future Impact of Technology on Work Skills," The World of Work, Bethesda, World Future Society, 1983, p. 252.

27 The report of the National Technology Policy Roundtable, Toronto, Ontario, September 23, 1986.

A number of avenues are open to the various levels of government, to private enterprise and to individuals. The solutions may be general, or even philosophical, or as concrete as they are commercial, but they all demand both time and money.

1. A concerted effort by government and private enterprise would thus be the first pre-requisite for achieving solutions with regard to an improvement in education and its harmonization with the job market.

2. Government and private enterprise must invest in research and development. This would keep Canada in the forefront of technologically innovative countries. That in turn would create new products, encourage investment, increase output, create jobs, etc.

This implies a change in attitudes regarding the importance of research.

3. There is a need for investment in business, both small and medium-sized, to encourage them to modernize, to buy advanced equipment and invest in the training and retraining of their work force.

4. There is a need for investment in the creation of jobs for students to encourage them to work in high-tech companies and to orient their course programs towards the areas of the future.

5. There is a need for investment in the purchase of computers and micro-computers for workers in plants and factories to encourage them to train in new fields better suited to the company's modernization requirements.

6. People must be encouraged to become familiar with electronic learning equipment by bringing the cost down.

7. Government and private enterprise must join together in a partnership to support our educational systems.

To what extent can these solutions be achieved? Is society--or even our governments--sufficiently aware of these questions and requirements?

Embryonic results

Certain suggestions are already at the embryonic stage. Some provinces have already set up, each in its own way, their individual programs to assist business, or to help job creation or workers, in order to stimulate the development, appearance and introduction of technology in the workplace.[28]

Certain provinces, such as Quebec, Nova Scotia and Alberta have established computer-related educational programs at the elementary and secondary levels.

Courses have been introduced and transmitted on-line to the most remote regions of the country.

Increasingly, the private sector is investing in employee training. IBM spends more than $700 million on employee training, while Xerox, RCA and Holiday Inns have their own training centres for the purpose.[29]

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28 Peat, Marwick et al., Canada-Nova Scotia information/communications sector study-Final Report, Halifax, January 1987.

29 Bertrand Yves, op. cit., p. 19.

Government is investing in UIRCs (University-industry Research Centres) and academic satellite businesses to encourage the R&D and subsequent marketing of experimental processes and products.

Several companies, such as Nothern Telecom, are involved in education. Their aim is to provide an opportunity to establish a durable interaction between educators, the world of information and communications technologies, for they know that "an educated workforce learns how to exploit new technology, an ignorant one becomes its victim" (Stonier's 1981).[30] And they know that investment in equipment and software, if it is not accompanied by sustained investment at an adequate level in human resources, will not produce a return (under-utilization). There is thus also an underlying argument of profitability.

Many exchanges have taken place between organizations such as CWARC and universities like the Université de Montréal and the Université du Québec à Montréal in order to promote research on, for example, artificial intelligence, and thus enable students and faculty to become more involved in the area of applications.

The aim of all these efforts is to move Canadian society along the path towards a society of excellence, in which the desire for improvement, determination and originality are equalled by its competitiveness in world markets.

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30 Hawridge, David, New information technology in Education, Baltimore, David Hawridge, 1983, p. 4.

Conclusion

In the course of this paper we have seen that the technological watershed we are experiencing at present is leading to a profound change in society, primarily in economic, social and educational terms.

The job market is undergoing a significant transformation as a result of the introduction and upsurge of these new technologies. Informatics accentuates the abstract nature of work with its figures and symbols. We therefore observe an increase in the mental component of the job (speed, attention, meticulousness, complexity, concentration) in the areas of production and design.

This is likely to lead to the introduction of key qualifications in the educational curriculum: understanding systems, manipulating information with the help of new technologies, planning, management, ability to communicate, to work in a team, to adapt, to learn and so on.

How can these abilities be taught, evaluated or even certified by diplomas? What learning methods and what environments are best suited to meet these needs? How can workers be trained rapidly and efficiently and how can their diplomas be saved from premature obsolescence?

The various political and industrial structures in this country are attempting to react to the technological watershed and the new "societal" orientation it has produced. The educational system is at the centre of the discussion and has every intention of monitoring closely the evolution of society as energetically as possible. It is clear that, while education cannot be ahead of changes in society, it tries as best it can to anticipate them.

There are nevertheless a number of persistent difficulties and problems. Opinions are divided concerning the educational contribution made by the computer in the schools (notwithstanding provincial policy statements) and a degree of distrust exists with regard to automation. Thus, in Ontario, a survey of 44,744 young people between the ages of 13 and 19 revealed that 60 percent thought that "computers cost too many jobs" (The Saturday Star, February 22, 1986). If no ones dares to face up to this type of personal worry and insecurity, the new technologies will have little chance of contributing to the well-being of society as a whole.

The technological watershed poses three challenges for the educational system: to train workers for the informatics industry, retrain workers affected by these changes and redefine the content of our education in light of the inconsistency between the education being provided and the new jobs being created.[31]

A new relationship to knowledge is developing. What will be the impact on the learners when, in spending more time on the computer, they spend more time thinking, solving problems, taking time for things that interest them, for their creative bent?

A new relationship to work is developing:

Do today's managers know how to derive the full benefit from technology by preparing the work environment adequately?

Are the various levels of government and private enterprise investing in human resources in such a way as to promote the adaptation of the work force to the new working conditions?

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31 Vallée, Guylaine, op. cit., p. 52.

Will the educational system be capable of providing the education, premises and services required for the optimal use of technology by man?

Will government and private enterprise unite in a true partnership to support our educational system?

Will our educational system be sufficiently sensitive to the needs of the world of tomorrow?

The object of this paper has been to make educators aware of the impact of technology on jobs. In particular, it was intended to raise questions and encourage educators to seek information from business and reseachers in order to remain alert to the developments that are affecting us all.

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